Anterior Segment Testing: An Eye Opener

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Financial Disclosure

- Amy Jost is a consultant to OptiMedica as part of the Medical Staff Advisory Board.
  - Consulting work has no influence on this presentation.
  - Commercial products are mentioned as comparative discussions. The speaker has no financial interest in any of the products mentioned in this presentation.

Objectives:

- To review the various instruments utilized during Anterior Segment Testing.
- Differentiate between various optical biometry devices.
- Discuss Ultrasound Biomicroscopy and its benefits.

Instruments for Anterior Segment Testing at CEI-BA

- Optical Biometers:
  - IOLMaster
  - LenStar
- A-scans:
  - Immersion Ultrasound
  - Contact Ultrasound
- UBM (Ultrasound Biomicroscopy)
- Pachymetry
- ECC/Specular Microscopy
- Slit Lamp Camera
- Portable Slit Lamp
- Pupillometer
- PAM
- RAM

- Keratometers:
  - Manual Keratometer
  - Orbscan
  - Pentacam
  - Trace
  - Atlas Topographer
  - EyeSys Topographer
  - Auto-Keratometer
  - IOLMaster
  - LenStar
  - Hand-Held Keratometer
  - Galilei G4
- Aberrometers:
  - WaveScan
  - Trace
  - Pentacam

Four Key Components Allow the Cataract Surgeon to Achieve The Planned Refractive Goal (for a normal eye)

- Axial length
- Keratometry
- IOL calculation and formulas
- Surgical technique

Normal Ranges

- Axial length = 22-25mm (average 23.5mm)
  - Axial length within 0.3 mm between the two eyes
  - Shorter or longer, run special IOL formula
- K reading = 43 to 45 diopters
  - Flatter or steeper
- ACD = 2.5 to 3.5mm (average 3.24mm)
- Lens Thickness = 3.5 to 5.0mm
- White-to-White = 10.5-12.5mm
  - Important to recheck if Toric IOL
Methods of Biometry

- Optical Biometry
  - IOLMaster
  - LENSTAR
- Ultrasound (A-scan)
  - Immersion
  - Contact

Optical Biometry

- Axial length
- Corneal curvature
- Anterior chamber depth
- White-to-white (WTW)

IOLMaster

Axial length
Corneal curvature
Anterior chamber depth
White-to-white (WTW)
IOLMaster Keratometry

- Keratometry
  - Measuring 6 points of cornea
  - Optical zone 2.5mm
  - One K reading is obtained by averaging 5 K’s

IOLMaster Keratometry

| Corneal Curvature Values | Average | Average | R1: 41.87 D @ 61 | R2: 42.83 D @ 151 | D1: -0.96 D @ 355 | D2: +1.16 D @ 103 | R3: 41.67 D @ 71 | R4: 42.03 D @ 151 | D3: +1.16 D @ 103 | D4: -0.96 D @ 355 | D5: 7.85 mm | D6: 7.85 mm |
|--------------------------|---------|---------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Average                  | 42.77 D @ 69 | 7.06 mm |
| Average                  | 42.04 D @ 43 | 7.97 mm |
| Average                  | 41.61 D @ 133 | 8.20 mm |
| Average                  | 42.40 D @ 43 | 7.96 mm |
| Average                  | 41.21 D @ 133 | 8.19 mm |
| Average                  | 42.45 D @ 40 | 7.95 mm |
| Average                  | 41.21 D @ 133 | 8.19 mm |
| Average                  | 42.45 D @ 40 | 7.95 mm |
| Average                  | 41.21 D @ 133 | 8.19 mm |
| Average                  | 42.45 D @ 40 | 7.95 mm |

IOLMaster ACD

Align for anterior chamber depth measurement

IOLMaster White-to-White

Available Calculation Formulas

- From IOLMaster version 5.4.4 and older
  - Holladay I
  - SRK/T
  - Haigis
  - Hoffer Q
  - SRK II (outdated)
  - Haigis- L (after corneal refractive surgery)
  - Phakic IOL
  - Prior Refractive Surgery (historical data)
**IOLMaster Technical Specs**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Range</th>
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<tbody>
<tr>
<td>Axial length</td>
<td>14 to 40 mm</td>
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<tr>
<td>Keratometry</td>
<td>6 to 10 mm</td>
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<tr>
<td>Anterior chamber depth</td>
<td>1.5 to 6.5 mm</td>
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<tr>
<td>Corneal diameter</td>
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<td>Pupillometry</td>
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<tr>
<td>Eccentricity of the visual axis</td>
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**LENSTAR Axial Length**

- Axial Length
- Keratometry
- Anterior Chamber Depth
- Corneal Diameter
- Lens Thickness
- Central Pachymetry
- Pupillometry
- Eccentricity of the Visual Axis

**LENSTAR Keratometry**

- Keratometry
  - Uses two concentric rings with 32 markers for precise measuring
  - Measuring two optical zones
    - 1.65mm and 2.3mm

**LENSTAR White-to-White**
Available Calculation Formulas

- Holladay I
- SRK/T
- Haigis
- Hoffer Q
- SRK II (outdated)
- Holladay II Integration Ready

LENSTAR Technical Specs

A-Scan Biometry

- Sounds waves are transmitted into the ocular tissues in the form of a sound beam. The sound beam encounters an interface and an echo (reflection) is produced which is transmitted back to the element within the probe.
- A-scan (amplitude scan) probe uses a flat element that produces a non-focused (parallel) sound beam
  - One dimensional echogram
  - 10 MHz frequency

General Reasons for Use

- Dense cataracts
- Poor fixation
- Measurements under anesthesia
- Confirmation of optical biometry

Echo Interpretation
Contact Ultrasound

- Correct Alignment
- Misalignment

Immersion Ultrasound

- Correct Alignment
- Misalignment

Probe Alignment

- Correct Alignment
- Misalignment

Localization of the Macula

- Helpful when using either contact or immersion especially when measuring a patient with a posterior staphyloma
  - Aim probe slightly nasal toward the optic disc for single retina spike
  - Shift probe slightly temporal to locate the macula

Tissue Velocities

- Cornea: 1,641 M/Sec
- Aqueous & Vitreous: 1,532 M/Sec
- Crystalline lens: 1,641 M/Sec
- Soft tissue: 1,550 M/Sec
- Silicone oil: 980 to 1,040 M/Sec
- Pseudophakic lens:
  - PMMA: 2,718 M/Sec
  - Silicone: 980 M/Sec
  - Acrylic: 2,120 M/Sec

Sources of Error in Biometry

- Corneal compression (contact method)
- Incorrect gate placement
- Gain settings either too high or too low
- Misalignment of the sound beam
- Incorrect sound velocity settings
UBMs
- Reichert® Reflex™ UBM
- MD-320W UBM by Meda Co.
- Compact Touch UTS/UBM by Quantel Medical

UBM Set-up
- Special cup to keep the eyelids open
- Filled with BSS
- Transducer positioned in the BSS ~2mm from the eye to avoid injury
- Measurements taken from multiple different angles

UBM
- UBM image of angle, iris, and zonules (arrow)
- UBM image at the limbus: scleral spur (black arrow), iris (downward arrow) and ciliary sulcus (thick left pointing arrow)

UBM
- Composite UBM image of the anterior segment

UBM Image of WTW vs. Sulcus

Visante OCT
- Non-contact device
- Provides imaging of the anterior segment
- Can measure anterior chamber, pachymetry, specific anatomical areas
- Measurements taken from different angles
IOL Vaulted Anteriorly

IOL in stable position

Visante OCT

Visante OCT

Visante Image of K-Pro

Keratometry

Methods of Keratometry

- Manual keratometer
- Optical Biometry: (IOLMaster, LenStar)
- Corneal Topographer
- Autokeratometer
- Hand-held keratometer

Keratometer
**Corneal Topography**

- Uses a placido disk technology of concentric rings located on the projection head assembly
- Measures the distance between the rings and their relationships with each other
- System can reconstruct the corneal surface with a higher degree of precision and identify micro irregularities

**Scheimpflug Imaging**

- The *Scheimpflug principle* is a geometric rule that describes the orientation of the plane of focus of an optical system (such as a camera) when the lens plane is not parallel to the image plane.
- Austrian army Captain Theodor Scheimpflug—correct perspective distortion in aerial photographs

**Pentacam**

- Topographic Maps:
  - Combined device:
    - Slit illumination
    - And a rotating Scheimpflug Camera

- Pachymetry-based IOP correction
- 4 Refractive Maps
- Anterior segment tomography
  - 3D anterior chamber analysis
  - Chamber angle
  - Chamber volume
  - Chamber depth
- Iris camera and HWTW
- Indices Reports: Glaucoma and Refractive screenings

- Scheimpflug Image:
Galilei G4
- Dual Scheimpflug analyzer with integrated Placido disc

- Pachymetry and elevation values
- The new Cone Location and Magnitude Index (CLMI), based on anterior axial curvature
- Ray-tracing for the real posterior surface

Visante Omni
- Anterior OCT
- Placido disk topography

iTrace
- Wavefront Exams-aberromer (refraction assessment)
- Corneal Topographer (map of cornea)

iTrace
- Corneal Topography
IOL Calculations

- Holladay I
  - Average axial length to long axial lengths
  - Uses a surgeon factor
- SRK/T
  - Average axial length to some short axial lengths
  - Uses an A-constant
- Hoffer Q
  - Shorter than normal axial lengths
  - Uses an ACD factor

Modern Formulas for IOL Calculations

- Formulas require the axial length and corneal curvature to predict the effective lens position (ELP)
- Formulas assume that the longer the eye, the deeper the ACD and the shorter the eye, the shallower the ACD
- Clinical cases have shown this is not always accurate

Haigis Formula

- Takes into account 3 constants:
  - $a_0$ tied to the lens constant, $a_1$ tied to the measured ACD, $a_2$ tied to the axial length measurement
- $d = a_0 + (a_1 \times ACD) + (a_2 \times AXL)$
Holladay II

- Axial length
- Corneal curvature
- ACD
- White-to-white
- Lens thickness
- Age
- Refractive error (prior to cataract if available)

Correlation of Errors to Postoperative Outcomes

- An error of 0.3 mm in the axial length measurement yields approximately 1 diopter postoperative refractive error on an average eye length.

- An error of 1 diopter with the keratometry measurement yields approximately 1 diopter post-operative refractive error.

Helpful Links

- www.doctor-hill.com
- www.docholladay.com
  Holladay II Software
- www.ascrs.com
- http://www.augenklinik.uni-wuerzburg.de/ulib/index.htm

Resource List

- Warren Hill, MD
  www.doctor-hill.com
- Sandra Frazier Byrne
  A-Scan Axial Eye Length Measurements, Published 1995
- ASCRS website: www.IOL.CALC.org

Any Questions?

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